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RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN ARGENTINA, BRAZIL, MEXICO AND VENEZUELA

prepared by

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CONTENTS

	Page
Preface	1 - 3
Research and Development in Microelectronics in Argentina	4 - 9
Research and Development in Microelectronics in Brazil	10 - 16
Research and Development in Microelectronics in Mexico	17 - 22
Research and Development of Microelectronics in Venezuela	23 - 30
Regional Cooperation in Research and Development in Microelectronics	31 - 33

PREFACE

In the four countries that have been analyzed there is a clear understanding of the important role that research and development could play in the future of the electronic industry and in particular in the future of microelectronics. It is recognized that microelectronics is an industrial field of high risk where local research and development capacity is needed even to be able to use foreign technology properly; such a capacity is even more necessary if the intention is to develop local technology not available from foreign sources in adequate conditions, for instance, when the intention is to manufacture strategic products for the internal market or for exports.

Training and development of specialized human resources is considered as a key element for the research and development strategy in this field. The support of higher learning institutions and universities that could contribute to form these human resources is also a very important point within the overall R&D strategy.

Considering the fast evolution of this industry, maximum interaction between production and research is an important objective in all these four countries. They have explored several ways to facilitate collaboration between research groups and industry and even to promote the establishment of research groups within industries themselves.

In all these countries there is a clear understanding of the important role that could be played by researchers as entrepreneurs and innovation promoters in industry. This is possible because their

knowledge gives them control over specific technologies, very valuable for existing enterprises or as a basis to start new high technology ventures. This movement of specialists seems to be a very good way to transfer technology between research groups and industry and to give them basis for long-term collaboration.

In the four countries there are effective means to finance research projects with medium-term objectives through governmental organizations responsible for the promotion of research and technological development, and also to provide funds for innovations promoted by industry, with high risks but with possible benefits in the short-term, through specific financial bodies.

The R&D infrastructure in the four countries is characterized by several common elements: the existence of electronic development groups in research institutes focused into specific sectors, like: telecommunications, oil, electricity, etc.; microelectronics development groups located in universities and higher learning institutions; and research and development activities with different levels of maturity in the most dynamic electronic companies. There are also some significant differences among them, such as the fact that Brazil has already an Informatic Technology Center (Centro de Tecnología Informática) that has, among others, a Microelectronic Research Institute that gives to this country a specialized infrastructure with and excellent scientific and technological capacity and a special industrial orientation that is not very common in other countries of Latin America.

The National Center for Research in Electronic Components (CENICE) of Argentina, is also designed to work within a national perspective in a long-term framework and with industrial orientation. It is therefore on the same lines as the Microelectronics Research Institute of Brazil, even though it has had fewer resources available. CENICE is within the general scheme of the Technological Research Center of the Armed Forces (CITEFA), has a very important technical

infrastructure and well defined plans focused into industry. Venezuela and Mexico do not have yet this type of research institutions devoted specifically to microelectronics research with an industrial focus. In Venezuela, the "Fundación Instituto de Ingeniería" has already a group with the technical capacity to undertake these functions. A specialized center to provide technical support to the electronic industry is being organized in Mexico under the sponsorship of the Government and industry.

In relation to national plans and policies to promote research and development in microelectronics, the four countries have great interest and different levels of definition. Without any doubt, Brazil has a better definition in its plans, programs and policies and good ways to implement them through a very wide political and institutional support and adequate infrastructure for research, development, training, services and coordination with industry. Argentina is working at high speed with similar objectives and has already important results in reference to: diagnosis of the present situation; legal and institutional mechanisms to define programs and projects with industry; specific plans to strenghten the R&D infrastructure in microelectronics, including that associated to human resource development; and a very precise definition of national objectives in this field.

In Venezuela and Mexico there is also a tendency for a better definition of plans and policies to promote microelectronics, both in the industrial aspects and also in those of R&D. The First Symposium on Electronics held in Venezuela in late 1984 with the support of several government departments, industry, universities and research institutes, set the basis for a national policy with long-term objectives in this field. In Mexico there are many activities within different governmental organizations and also within industry and research groups, that very likely will merge in a short time in a national policy in this subject.

Summing up, it could be concluded that in these four countries there is a strong basis to promote a very fast development of R&D in microelectronics.

RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN ARGENTINA

Argentina is a country with a very important scientific and technological infrastructure, with a very high level of education and with a great potential to develop and industrialize technological advances in microelectronics. In the last ten years Argentina has been through a process locally called "desindustrialización" by which many companies have closed or were bought by foreign companies. The latest industrial policy is changing this, and is giving special attention to sectors like informatics, telecommunications, microelectronics and electronics in general, because they are very dynamic and because they can be integrated to a national strategy to improve the efficiency of the productive sector, stimulating at the same time exports, imports substitution and the country's technological development.

Since the 60s there were several activities started in microelectronics in Argentina. By 1974 there was already some work done in the development of silicon planar transistors in the microelectronics group of CITEFA (Centro de Investigación Tecnológica de las Fuerzas Armadas). This group was later integrated to the new CENICE (Centro Nacional de Investigación en Componentes Electrónicas) when this was created in 1977. This new center had the support of government institutions that represent the sectors of science and technology, industry and defense. CENICE has become an organization capable to produce special devices, such as hybrid circuits of high quality, and able also to advise industry and government in relation to the design and fabrication of microelectronic components, as well as to undertake directly testing and technological development activities in this field.

Within the Argentine Government, the "Secretaría de Ciencia y Técnica" is responsible to coördinate the National Program in Electronics, established more than ten years ago. This program

has channeled different kind of support to research groups, giving them guidance to work within national priorities and avoiding unnecessary duplications.

There are several groups undertaking R&D activities in microelectronics, most of them within universities and research centers. We can mention here the universities of: Buenos Aires, La Plata, El Litoral, Córdoba, Tucumán, Cuyo, Del Sur. and institutions like INTI (Instituto Nacional de Tecnología Industrial), the Bariloche Atomic Center, the National Telecommunications Laboratories (LANTEL), CENICE and other groups form CITEFA.

It is estimated that in all these groups there are more than 1000 professionals -most of them electronic engineers- including researchers, support personnel and trainees in different areas of development or applications of microelectronics, not including those working in software development.

As was mentioned in the Preface, Argentina shows a high degree of maturity in the definition of a national policy in microelectronics. The report of the "Comisión Nacional de Informática" dated October 1984, in its preliminary version for discussion, shows a clear description of the National Strategic Project in this field, that reflects the importance the Argentine Government is giving to the integrated field of informatics, telecommunications and electronics, pointing out also toward specific actions in relation to industry, technology, law and training, to promote the development in this field.

The "Comisión Nacional de Informática" was created under the new government, with participation of the "Secretarios" of: Science and Technology, Industry, Communications and Public Function. This Commission is therefore at the highest governmental level, corresponding to the importance given to this field. The Commission's report gives a very special role to R&D; it very clearly

states that the technological capacity of industry, added to that of the research institutes that support them, determines the ability to compete and the potential for growth of industry.

The need to acquire and assimilate technologies from other countries is recognized, given that the assimilation is done fully and with the support of R&D activities closely linked with the industrial practice. The importance of adequate training and proper orientation to human resources development programs for this field is fully recognized, starting with good engineering and science schools, and considering that the personnel that participate in research and development are actually obtaining an advanced level of training as well.

The Commission's report underlines some characteristics of microelectronics technology that make it specially interesting for a country like Argentina. It shows, for example, that it is a technology that has been widely spread and that is also relatively accessible. The advances in large scale integrated circuits design tools and manufacturing processes, for instance, could be acquired internationally, at least most of them, from several suppliers that are competing among themselves. National markets present big opportunities for local industry if competitive developments are achieved and with adequate technological capacity industry they could also have access to "niches" of the world market.

It is also recognized that industries associated with microelectronics have high risk and live with technological barriers that constitute the main problem to achieve independence of action and improve local development. Therefore, local technological development has a big priority to allow companies to brake barriers, to diminish risks and to follow their own strategies. It is also noted that there is a special phenomenon in the sector associated to the difficulties to protect research results that could be transferred by

specialists of research groups to industry. It is mentioned that researchers frequently move out to start their own industries or to participate in other industries, generally new, in which they play a very important role. This leads to the conclusion that it is a government responsibility to promote the development of research infrastructure in this field, and assume that it is a natural process that some researchers will move with key knowledge out to industry.

In reference to industrial development, the report indicates the need to strenghten an industry that should be innovative, independent and competitive, because this kind of industry has the mechanism to assimilate and develop local technology. Some technological criteria are also given to identify areas in which industrial opportunities could be found: accessible technology, efficient for the levels of production than could be attained locally, intensive in local technology, with foreign technological inputs that could become accessible, related to flexible processes, not requiring large investments and allowing local subcontracting of components with maximum national integration.

With reference to research and development, it is proposed to invest 5% of sales and to promote collaboration among enterprises and research groups. It is also recommended to take advantage of the research capacity to offer specialized technical services, such as: standardization, homologation, quality control, tests, specialized advise, technical support for the acquisition of materials and equipment, support to the disaggregation of systems, technology transfer information services and follow-up national trends in this field.

Another important recommendation is to review the evaluation criteria of CONICET researchers. It is claimed that the evaluation mechanisms that have been followed in the past do not agree

with the characteristics of technological research, because they are based on those of basic sciences. It is also noted that under the "technological domain", the originality concept should not be applied in traditional absolute sense, but considering that in many cases it might be necessary to produce knowledge locally, that is already available for other countries, and not available for Argentina, as it is the case in some microelectronic processes. It is recommended to consider in the evaluation of researchers, the applicability of their results and their work in supporting technology transfer, that sometimes is taken as routine engineering that "waste research resources".

In reference to the training of technicians and specialists, it is recognized that the achievement of high professional and technical qualifications has a great importance, and therefore it is needed to promote the training of teachers in the research environment where they can also be in touch with the world network in which the new concepts are being developed. It is considered that in this way teachers will be able to transfer the spirit of research that students require.

It is proposed that the promotion of new developments should include areas within the following subsectors: Data-processing equipments; telecommunications, electronic equipment for offices; industrial electronics (process control, electro-medicine, automatic instrumentation, robotics) and electronic components. Special mention is made about the importance of software development, starting with the training of specialists and the development of software developments tools. In microelectronics it is proposed to create new capacity for the design of custom and semi-custom circuits, in order to take advantage of the facilities of silicon foundries that could be subcontracted elsewhere. In the subprogram of microelectronics and components, the National Electronics Program makes the following proposals:

1. To recommend scientific and technological research activities in amorphus, polychrystalline and single-chrystal silicon, with the purpose to conceptualize design and manufacture highly reliable integrated circuits.

2. To ensure the capacity to develop MOS integrated circuits of specific design, without endangering the support to the study and manufacturing of other types of integrated circuits.

3. To recommend scientific-technological research in semiconductors complementary of those made out of silicon to develop devices of different complexities and the R&D related to their applications in electronics, opto-electronics, detectors, microwaves, etc.

4. To develop electronic component technologies that could complement activities referred in items 1, 2, and 3, such as: capacitors, thin-film registors, small-size energy sources, insulated ceramics, monolitic ceramic filters, etc.

5. To develop the technologies related to the systems that use the components mentioned before.

6. To maintain adequate capacity to study basic problems related to the subjects that have been already indicated.

With this brief description of what is happening in microelectronics in Argentina, it could be said that this country is considering it as a priority area within its industrial development strategies. There is no doubt that in the next few years Argentina will have important advances in this field, with big effects on regional cooperation in microelectronics.

RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN BRAZIL

Brazil's strategy for research and development in microelectronics is based on the recognition of the importance of this field as a way to facilitate competitiveness and innovation capacity in the different branches of electronics.

It is considered that this capacity, specially in reference to the design and fabrication of printed, hybrid and integrated circuits of different levels of complexity and also of other electronic components, is the most important element to insure the competitiveness of electronic industry.

Microelectronics is obtaining a very strong support within the informatics strategy of the country; the microelectronics program was elaborated with the support ot the "Secretaría de Estado para la Informática" (SEI) working in coordination with TELEBRAS, FINEP and other organizations. The Microelectronics Institute is a part of the Center for Informatics Technology, that has been created recently. Because all of this, it is necessary to start analyzing Brazil's policy and plans in informatics to understand the framework for its development in microelectronics.

After the establishment in 1976 of the National Policy of Informatics (PNI) Brazil has had means to formulate a long-term program for R&D in this field very closely linked with the development objectives of the country.

The "Secretaría de Estado para la Informática" (SEI), created in 1979, organized a series of measures to promote research and development demands related to hardware, software, components and peripherals, as well as to the applications of informatics.

Brazil's research and development infrastructure in this field is very broad. It includes very strong research groups in universities

like those of Sao Paulo and Campinhas and also in research institutes focused to specific sectors like petroleum, electricity, aeronautics, etc. In most of these groups there has been important advances in informatics, specially in software development for specific applications.

The Brazilian industry has responded very favorably to the national policy of informatics, developing products with their own technology and covering more than 45% of the market with products that have very high level of national integration: 95% for the central unit, the keyboard and the monitor in micro-computers, for example, or, as in the case of the Cobra 500 mini-computers, that is reaching 97% in machines totally designed in Brazil.

A fundamental premise of Brazil's National Program in Informatics is to ensure that local industry develops its own technical capacity, using what is called the "market reserve mechanism to create conditions to develop national technology". Industry is requested to operate with its own technology, The agreements to use foreign technology must be for a limited time and with the assurance that they will be used to develop local capacity.

The results have been very impressive. The development of their own technology has allowed companies to cover the continuosly growing segment of the market products that are internationally competitive, generating an increasing number of new employments (110% more than the multi-nationals for 1983) not only for workers, but also for engineers and researchers; to increase national integration levels above 90% and to provide bases for the export of informatics products. Brazil's previous experience in the aeronautics and war material industries shows that technological autonomy is a pre-requisite to export products in high technology sectors like informatics.

Brazil's informatics policy has often been under attack under the supposition that it is leaving the country with "third quality" technologies. The truth is different. In reference to microcomputers hardware, Brazil equipments are using the most advanced integrated circuits and are side by side with those of other countries, mainly because of the R&D work done locally. Brazil's peripherals have been lagging behind mainly because of technological weakness in precision mechanics, but they have now been superated by the new models for printers, disc drives and others. In relation to software, Brazil has more than 83,000 professionals working in its development, even for the so-called "basic" software, like operating systems and compilers, that has been developed by groups within the universities.

Industry's R&D activities in informatics, as well of those from the universities and from sectorial institutes in this field, will be supported by the new Informatics Technology Center (CTI) through its Computation Institute, that will be working in areas like basic software, specifically in: compilers, operating systems, editors, tools for facilitating and automating software development, etc.

The Computation Institute will also work in the following areas: to develop interphases to link Brazilian peripherals with large foreign machines; support to software development for specific sectors, like medicine; to develop standards and certification mechanisms for programs and equipment; it will certify,from a technical point of view, industries' integration plans and will help to identify and take advantage of new opportunities to increase integration and start the manufacturing of new products. It will help also in the analysis of import permits and through new specialized laboratories will also be able to study different phenomena related to the life and performance of equipment such as: tolerance to varying electrical supply conditions; electromagnetic interference; the life of components, boards and complete equipments.

Besides, the Microelectronic Institute that will be described later on, the Informatics Technology Center has also two other institutes in the areas of automation and instrumentation. The Automation Institute has three departments: Process Control, Manufacturing Automation and Advanced Engineering; it is undertaking projects within industry, like, for example: Control systems for aluminum furnaces; CAD-CAM system with manufacturing companies and is also developing distributed control systems. The Instrumentation Institute has also three groups: sensors and actuators; instrument maintenance (medical instruments for hospitals, mainly); and standards. This Institute is working in the development, for example, of certification procedures (that later on it will transfer to other institutes). It is collaborating with the National Metrological Institute and with the Underwriters Laboratories in the United States to certify exports; it is also collaborating with industry in the design and installation of measuring systems for quality control, for example, of printed boards; among other functions to support the manufacturing of components and devices, it is working with the SEI in studies to promote import substitution, for example, of step motors that are used in peripherals, of special materials and others.

The Informatics Technology Center works very closely with industry to promote the manufacturing of products that will substitute imports, and to adapt them to the needs, the materials and the manufacturing capabilities of the country.

Companies that are users of electronic equipment in Brazil like TELEBRAS and also manufacturers of this kind of equipment like the ITAU Group, are organizing design groups for integrated circuits, in some cases. They also have capacity to manufacture them. This is a sample of the advanced technological level of many industries in this country and also of the scientific and technological demand that has been generated in this field.

There are other industries like AEGIS and HELIODINAMICA, manufacturing power diodes and solar cells respectively, with locally developed semiconductor technologies, that are an example of the excellent interaction that has been achieved between research groups and industry.

Many of these results are based on the research and development work started more than 15 years ago in universities like those of Sao Paulo and Campinhas. It is also found that many of the promoters of the new companies, the technical leaders of the industrial groups and the heads of the new research institutes were formed within the research centers of the universities. All of this shows many of the benefits that came out from the important and continued support that has been given to scientific and technological research in microelectronics in Brazil for more than a decade.

The recent establishment of the Microelectronics Institute, within the Informatics Technologies Center and under the broad umbrella of the Brazilian Informatics Policy (PBI), provides stronger basis for R&D activities. The new market for informatic equipment opened by the PBI is widening the demand for microelectronics and also promoting research and development to fulfill this demand. The solid infrastructure of the Microelectronics Institute will allow important advances in the design and in the manufacturing technologies for integrated circuits and has became a strong support for other research groups that could use this powerfull infrastructure, through consultancy and technical services, to develop their own prototypes.

The microelectronics research and development program of Brazil was established under the promotion of a high level group intergrated by the "Secretaría de Estado para la Informática" (SEI) TELEBRAS and FINEP (Finance Fund for Research Projects). To elaborate this program, a Technical Consultative Council, chaired

by the Director of the Microelectronics Institute, was established with the participation of selected specialists. The program defines objectives and priorities for R&D projects. With this basis the research centers could find an orientation to develop their own infrastructure and to submit proposals for projects that besides being relevant could be coordinated and complemented with those that are being realized by other institutions.

There is no doubt that Brazil has already the instruments, the policies and the demand to go on with a very ambitious research and development program in microelectronics. Two of the main objectives of the program are to ensure that the country will have the minimum capacity required to be independent from foreign suppliers of strategics materials and components and to maximize the competitiveness of Brazil industries in this field.

Some of the areas with high priority within the program are the following:

1. Capacity to design integrated circuits, considering semi and full custom; design strategies and techniques; design for testability; design tools including lay-out testing and simulation; models of devices.

2. Scientific and technological capacity required for manufacturing process of integrated circuits, including: preparation of substrates and their physical properties; thermal oxidation; thermal deposit of dopants; ionic implantation; standardization or nitrates; masks; lithography; materials corrosion; chemical cleaning processes; encapsulation process equipment; methods and devices for the characterization of processes; models for processes; etc.

3. Applications for new materials; processes and new structures in microelectronics.

4. Basic inputs for microelectronics; semi-conductor materials; chemical products; photolithography and encapsulating materials; metals; gases, etc.

5. Measuring techniques for microelectronics; characterization of materials for sustrates and conducting films; characterization of different process stages and devices; integrated circuit characteristics; electrical testing, etc.

This research and development program is based on the coordination between industry, research groups, universities and the different government organizations related with this field. This coordination is essential to ensure that research is well oriented, with adequate governmental support and contributing to the training of specialists, that is one of the highest priorities of Brazil's technological policy in microelectronics.

To promote the training of scientists, engineers and technicians, strong support is given to technical schools and universities, including resources for infrastructure and better salaries for researchers. This is done by the financing of projects selected because of its quality and relevance. This financing gives extra salaries, amounting up to 50%, to the researchers, ensuring, on the other hand, that they have adequate working conditions.

It can be added, as a short synthesis that Brazil's program for R&D in microelectronics has very important innovations that could guide and inspire activities of the same type in other countries.

RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN MEXICO

The National Program for Scientific and Technological Development in Mexico gives special priority to electronics, mainly because of its importance in the structural change that is intended for Mexican industry. Given that electronics is an activity based on advanced technology, high priority is placed to research, development, training and technical services activities that will support it. The National Council for Science and Technology has an electronics program through which resources are channeled to support infrastructure for research institutions and to finance specific projects.

In other areas of Government there is also special attention to electronics and the associated research and development activities. The Ministry of Communications and Transport is promoting research activities in telecommunications and is also creating a national institute in this field. This institute will give a broader scope to the work that has been undertaken by the former Research and Development Center in Telecommunications (CIDET) that has been operating within the Ministry. This new Institute, created as an independent organization, will have greater operational flexibility, better conditions to integrate, develop and keep high level personnel, and better support to focus their work on the medium-range needs of the country. This same Ministry is also promoting research and development activities within universities and telecommunications industries through its recently created General Direction for Research and Technological Development. R&D has been oriented to the National Telecommunications Program priorities, and includes : the modernization and broadening of the federal microwave network; satellite communications and digitalized telephonic networks as well as its integral

use for voice, video data transmission and improvements in radiomaritime communications, among other subjects.

The Ministry of Commerce and Industrial Development is responsible for the electronic industry manufacturing program and has given special attention to the subsector of computers and peripherals. Before 1981, most of this equipment was imported. Between 1981 and 1983, 42 programs to manufacture locally were approved, from which 20 were related to microcomputers, 12 for mini-computers, 17 for peripheral equipment and 4 for control systems. To date there are nearly 80 programs registered. The Ministry is promoting R&D activities of these companies by asking them explicity to devote at least 5% of their sales to this kind of work; priority is been given to projects that are contracted with independent research institutions with the purpose to multiply and strenghten the national technological capacity in this field.

The Ministry of Energy, Mines and State Industry is giving special importance to electronics as a way to promote the acceleration of technological change and the modernization of many of the industries belonging to this sector. It considers electronics also as an essential area in which it is possible to use the buying power of the State, and the research and development capacity of the sector, to promote electronic enterprises that could become internationally competitive and could have also a very important effect in the local manufacturing of materials and components. The "Centro de Evaluación de Proyectos" (Projects Evaluation Center) in this Ministry, prepared recently a report that presents a global diagnosis of this field and gives special recommendations for a general plan of action that gives special importance to the scientifical and technical infrastructure related to this field. In particular it is clearly stated that: " The materialization of

the objectives that have been stated depends, in a fundamental way, on a big and well organized effort in the areas of research and development, training and human resources".

The Ministry is basing its program on the activities of the research institute within its area of competence, such as those in oil, electricity, steel and nuclear research. The electronic activities of these institutes are focused mainly on specific applications and there are also some activities to develop electronic circuits design tools and to provide technical support to the manufacturing of circuits and equipments. This Ministry has also proposed the possibility to organize a new center for research and technical services in electronics that could start with technical services to the electronic industry and could be established with the cooperation of industry and the professional community in electronics.

In the past, electronic research undertaken by universities and technical schools has been, according to the National Council for Science and Technology, "Undertaken without proper order and without precise industrial objectives", "it is not difficult to find appearance and disappearance of research lines because many of them have been sustained on the basis of personalities and not on true master plans that will determine clear priorities and strong institutional commitments", "a proper level of technology transfer has not been achieved yet between the research made in specialized educational institutions and the sector that produces goods and services".

This situation is bound to change, specially in independent research institutions where more than 20 new electronic products have been successfully transferred to several industries.

Some of the most important R&D groups in electronics are the following :

In telecommunications there is the strong participation of the Center for Research and Advances Studies (CINVESTAV) with its Electrical Engineering Department (Rural telephonic exchanges, manual and automatic, modem testers, microwave networks for telemeasuring, supervision and linkage). The Metropolitan Autonomous University (UAM) with private - telephone exchanges, automated telegraphic exchanges .

The National Autonomous University through its Engineering Faculty (speech recognition systems and devices, modems,etc.).

The Scientific Research and Higher Education Center in Ensenada (CICESE) (Radio telephony, network planning, digital commutation for rural areas). The Research and Development Center in Telecommunications (CIDET) (metrology, standardization homologation, microwaves and data transmission systems and equipments). The Telephone Company (TELMEX) research group (automatic digital exchanges, fault detection, long-distance call... meters, alarm detectors).

The Electrical Research Institute (IIE) (remote-terminal units, fiber optics, carrier,microwave networks . INDETELEC (telephone exchanges, telephones, digital radio systems for rural telephony, microwave equipments). Some small private industries in the area (modems and telephone exchanges). .

In instrumentation, there is also work being done through the Instrument Center of the National Autonomous University (UNAM) (power supplies, test and measuring equipment) the National Institute for Nuclear Research (measuring equipment), and the Petroleum Institute (IMP) (measuring equipment), among others.

Process control research has been performed by the UAM (adaptive control); the "Escuela Superior de Ingeniería Mecánica y Eléctrica" (ESIME) (data acquisition system); the National Autonomous University (UNAM) (systems for the control of water supply networks); the "Instituto Tecnológico y de Estudios Superiores de Monterrey" (ITESM) (digital process control systems); the Regional Technological Institute of Tlalnepantla (numerical control of machines and machine tools), the Electrical Engineering Department of the CINVESTAV (fermentation systems control); the IIE (programmable controlers, sequence controlers, electronic equipment for instrumentation and control systems); the IMP (process control systems and equipment).

There are also several groups working in biomedical equipment, mainly at the CINVESTAV, the Social Security Institute, the Cardiology Center, the Medicine School and the Mechanical and Electrical Engineering School of the National Polytechnic Institute (IPN) and the Iztacala unit of the UNAM.
There are three important groups working in semiconductors. The Electrical Engineering Department of the CINVESTAV; the National Institute of Astrophysics , Optics and Electronics and Puebla's Autonomous University. The first two are working on the fundamental processes to design and manufacture discrete power devices and MOS integrated circuits of low complexity, starting from the wafers; in the third group R&D activities started with the development of laboratory equipment necessary to experiment the fundamental processes of this technology (high temperature furnaces, testing machines, temperature controllers, equipment, etc.). Also the Physics and Materials Institute of the UNAM are working on monocrystaline silicon and amorphous silicon respectively, and they have plans to broader their capacity related to materials and components for microelectronics.

In informatics there are also groups developing new products in industry (MEXEL, Micrológica Aplicada, Transdata and Link, among others) and in research institutes like the Electrical Engineering Department of the CINVESTAV, several institutes within the UNAM (Research Institute on Applied Mathematics, Systems and Services, Instrumentation Center, University Program for Computers); the Electrical Research Institute (IIE), and in the Mexican Petroleum Institute (IMP), among others.

Practically all the groups that have been reported, have been working in the past with institutions of other latin-american countries, specially at the level of technical visits, inform - ation exchanges and participation in regional meetings.

In microelectronics it is appreciated that there is little interaction between research and industry. This is due principally to the incipient industrial development in this field and also to the fact that design and development groups working with equipment and devices have not been interested so far in more intense utilization of custom and semi-custom integrated circuits. There is already a big interest in the possibility of establishing a center to provide technical support to the electronic industry for electronic circuits design, interaction with silicon foundries and in general for the development and evaluation of electronic equipment. This center could also improve the collaboration between industry and research institutions, facilitating the industrial application of research results and also the identification of opportunities for new projects.

RESEARCH AND DEVELOPMENT OF MICROELECTRONICS IN VENEZUELA

The Government in Venezuela has announced that the subsector of electronics, telecommunications and informatics has been included as one of the priority aspects of the VII Plan of the Nation. It is considered as a catalyser element for the scientific and technological progress that should follow the autodetermined integral development that the country is looking for.

In the I Symposium of Electronics that was held in Caracas in November 1984, it was concluded among other things, that :

- There exist several good conditions for the development of electronics technologies through innovative national enterprises that have arisen after 1974, and that are designing, fabricating and commercializing to the point that have already achieved significant levels of sales in the country. It is recognized that these companies have been favored by factors such as:

  . Availability of highly qualified engineers.
  . Advantages of having the capacity to design according to the needs of the local markets; to give better service and maintenance and to compete in quality and price with foreign products.
  . Availability of risk capital and ,
  . Availability of technical support through universities and research centers.

- It is necessary to strenghten the institutional framework for the development of this subsector through: the establishment of a new consultative organization at high

level; additional support from the armed forces to develop the scientific research and technical development infrastructure; strenghtening of research infrastructure for microelectronics and informatics; the establishment of specialized information and technical services; strenghtening and coordination of the installed capacity for research.

- It is also recommended to establish a series of actions and mechanisms to improve the communication within the subsector, such as :

  . To produce, through the professional electronic enterprises association, the catalog of products, services and technical capacities of the different companies
  . To give continuity to the Electronic Symposium and to edit an annual publication about it.
  . To improve the communication with the armed forces.

The fact that the I Electronic Symposium was organized with the participation of the Ministries of Defense, Industrial Promotion, Education and Science and Technology, and also with that of the Central University, the Engineering Foundation and the Professional Electronics Association, shows the great interest that exists in Venezuela, in all these sectors, to establish the appropriate framework to favor the development of electronics and in particular of microelectronics. Venezuela has a clear understanding of the potential that the country has in this field and the benefits that could be obtained from it.

Through the National Council of Scientific and Technological Research (CONICIT) it has been proposed to create the Commission

for the Development of the Research and its Applications in Microelectronics. This Commission should study the state of microelectronics in Venezuela and the feasibility to establish industrial plants for integrated circuits, components and electronic parts. Among the areas of possible studies of the Commission, the following have been indicated :

a. Integrated circuits
b. Integrated devices
c. Hybrid circuits
d. Optic fiber systems and devices
e. Active and passive microwave devices
f. Automated systems
g. Microprocessors applications

It is also recommended that the Commission "provides guidelines to establish appropriate quality control and standardization systems that are needed for the sector and also indications about the mechanisms to favor better ties between research and industry."

The R&D activities in microelectronics in Venezuela are concentrated mainly in the "Fundación Instituto de Ingeniería", in the Venezuelan electronic industries and in the institutes associated to specific sectors like the Venezuelan Petroleum Institute, the research groups of the Venezuelan Telephone Company (CANTV) and in the institutions like the Venezuelan Institute of Scientific Research (IVIC), the Central University and the Simón Bolívar University; these universities and the IVIC also play a very important role in training specialized personnel for this area.

The "Fundación Instituto de Ingeniería" is the most active organization in this field with high technology projects of industrial relevance, in fields like hybrid circuits, solar cells and power diodes. The "Fundación" has the objective to maintain

a high level of scientific and technological quality in its work and is therefore making big efforts to train their personnel in the best universities. At this moment they have 5 PhD students in foreign universities in different areas of microelectronics. For the near future "Fundación" has specific goals related to the computational systems to support the design of electronics circuits and in different technological aspects related to the manufacturing of circuits. Taking advantage of the silicon foundries available in other countries, they have considered the fabrication of custom and semi-custom circuits for telephone system applications, as a first step in this direction. In the area of telecomunications, the "Fundación" is also looking to improve its capacity in fiber optics and digital linkages through microwaves; it is also trying to widen its line of microprocessor applications extending its present developments in local area networks to microprocessors networks for the control of industrial plants and also networks for office automation.

Venezuelan industries are very active in technological development, most of the companies created in the last 10 years have their own technical capacity and they have also been able to commercialize efficiently their own products. They have used this technical capacity to improve their negotiation capabilities when they acquire complementary technology from other companies. Some of the examples of products developed by these companies are the following :

AETI. Supervisory control and data acquisition systems.
AVTEK. Voltage regulators. Insulator transformers. Line conditioners. Uninterruptable power supplies.
DISTELCA. Office automation software. Telex computer interphases.

EYT. Supervisory system for lifts. Street light control systems. Telemetry and control system. Telephone equipment.

FABELCA. Control microcomputers. Software systems. Programmable controlers. Maintenance services for microcomputerized equipments.

FONOLAB. Telephone devices. Operations tables. Communication display systems. Telephone exchanges interphases and adapters. Rural public telephone exchanges. Telephone exchanges. Combined telephoning systems.

INTERBA . Taxi-meter. Speed register.

MICROTEL. Systems to identify telephone suscriptors. Telephone exchanges. Control systems for lifts. Rural telephone exchanges.

VOLTEK. Autonomous clocks. Centralized clocks. Information displays.

XYNERTEC. IBM-PC compatible microcomputers based on foreign technology with a local technology integration program that will allow it to dominate all the electronic circuit plus the frame and power sources.

Most of these companies have been organized after 1975 and have been growing at an annual average rate of the order of 45% . All of them are based on their own technology and have given a great emphasis to commercialization, user's services and to adaptation of their programs to specific requirements of the user and to insure competitiveness in quality and price. A difference with companies of other sectors is that in these companies there is a permanent dedication to the R&D activities ant that is why they have about 40% of their engineers and

technicians devoted to this type of activities.

It is interesting to observe that many of these professional electronic companies have been initiated with managerial efforts of highly qualified engineers that have developed their own products, with their own design and engineering, as a starting point of their companies. In general, their initial rate of return has been low; as the companies have been learning to develop their own products, improving their own design and engineering, the rate of return has improved and at the same time they have been able to take a larger share of the market. A report produced by Mr. Carlos Chacón L. in August 1984 points out: "The fact that this small number of enterprises have developed and commercialized more than 30 products, many of them incorporating advanced technology, give us a good measure of their technological capacity in the application of electronic technologies and it also suggest their high potential for the development of systems and equipments much more complex than those that have been designed and adapted for the specific needs of the market so far". Mr. Chacón reports also the fact that, during the last three years, these companies have initiated on the average about seven new R&D projects each year, with significant investments in each of them.

Successful research projects include the development of commercial products, both in hardware and software. They have been achieved because of the high qualifications of their engineering personnel, many of them with postgraduate degrees and with previous experience in research institutions.

It is important to underline, from the same report of Mr. Chacón, the strategy elements that these industries have been

using to define their products:

a. To take advantage of the market "niches" generated by local conditions that demand equipment with different specifications than those used standardly elsewhere.

	IMPORTED	NATIONAL
* Voltage regulators with wider operational range. Voltage variation range	15%	25%

b. Universal designs that allows the compatibility among equipments of different origin and the modernization of obsolete equipment.
   * Digital interphases to identify telephone subscribers and to allow direct international dialing in electromechanical telephone exchanges.
   * Multi-frequential signaling for decadic telephone exchanges.
   * Detailed billing system (DDN)
   * Telex-computer interphase.

c. Designs incorporating recent components, achieving the fabrication of more advanced equipment than those that are available at the moment in the international market.
   * Telephonic exchanges PABX, incorporating a series of special characteristics to improve those existing in the market.
   * Modular street light system with distributed control
   * Design of systems and equipment with appropriate specifications for the particular needs of the user.
   * Lift control system

The young Venezuelan electronic industry is giving signs of dynamism, strength and competitiveness that indicates the great potential it has for future development, if there is a more ambitious governmental policy to support electronics. It

is very likely that a governmental policy will be designed with some of the following objectives : To make a better use of the national market, and specifically of the public sector market, to favor preferential financing for R&D activities, to devote more resources for the research and development groups in the universities and institutes. With these kind of policies it is foreseeable that the process of establishment and development of electronic companies will be accelerated with an important multiplying effect in the Venezuelan economy.

REGIONAL COOPERATION IN RESEARCH AND DEVELOPMENT IN MICRO-ELECTRONICS.

There is no doubt that in the long range the only way for the Latin American Countries to achieve a significant role in microelectronics at the world level is on the bases of a regional cooperation. In this way it could be possible to take advantage of the market, the industrial capacity and the scientific and technological potential of the region as a whole.

This cooperation would benefit countries least advanced in this field through the training of human resources, the support to start application programs, and the understanding of tools and processes that are in use or in development in other countries of the region, and in general, to facilitate them the access to information and experiences of great value to define opportunities, plans and specific programs.

All countries in the region, and specially those that are more advanced, could benefit from the access to markets, innovations and human resources of the whole region. At the same time it is possible to think in terms of more ambitious regional programs and projects, that could not be feasible with the resources of one country alone.

Regional cooperation in human resources could take advantage of the very costly infrastructure of laboratories, computers and specialized installations of the microelectronic groups in the different higher learning institutions, favoring complementation and better use of the resources. The advantages in language, culture and geographic vecinity, could mean an acceleration in the training of specialists. This cooperation

could mean also the use of the region's resources in the region itself, minimizing external flows of foreign exchange because of this concept.

The realization of cooperation projects like the "multi-project chip" that is suggested in the report of the mission to Venezuela, Brazil and Argentina,* will allow not only to share experiences and to accelerate the development of associated technologies in each country, but also to facilitate the communication among research groups and industries in the whole region, ensuring future benefits coming from a greater collaboration.

The dynamic performance of industries in informatics, telecommunications, professional electronics and electronics in general, within the region, opens very big opportunities for industrial and technological complementation. This complementation could be achieved as far as there are better basis in each country to identify opportunities to understand and evaluate what is being done in other countries in the region and to assimilate and apply electronic technologies.

There is a difference between what has been observed before in fields like consumer electronics, in which each country was pretending to have everything necessary to produce locally a whole range of products with little margin for regional complementation, and what happens now in the fields of informatics, telecommunications, professional electronics and microelectronics as such, that are so wide, complex and dynamic that open real and big possibilities for complementation; it becomes not only pretentious, but practically impossible for one country alone to cover the full spectrum of possibilities.

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* See document ID/WG.440/5.

The suggestions made in the mission's report that was mentioned before, to promote meetings, publications and broader regional communication among researchers, industrialists and authorities, could facilitate the definition of more specific opportunities for scientific and technical cooperation and also opportunities to improve the existing mechanisms to finance, promote and coordinate this cooperation. Acoording to the observations of the same mission and considering what has been said in this report about research and development in microelectronics in Latin-America, it can be assured that the establishment of the "Red Microelectrónica Latinoamericana" (REMLAC) will favor cooperation not only in research and development, but also in different industrial an commercial aspects in this field.